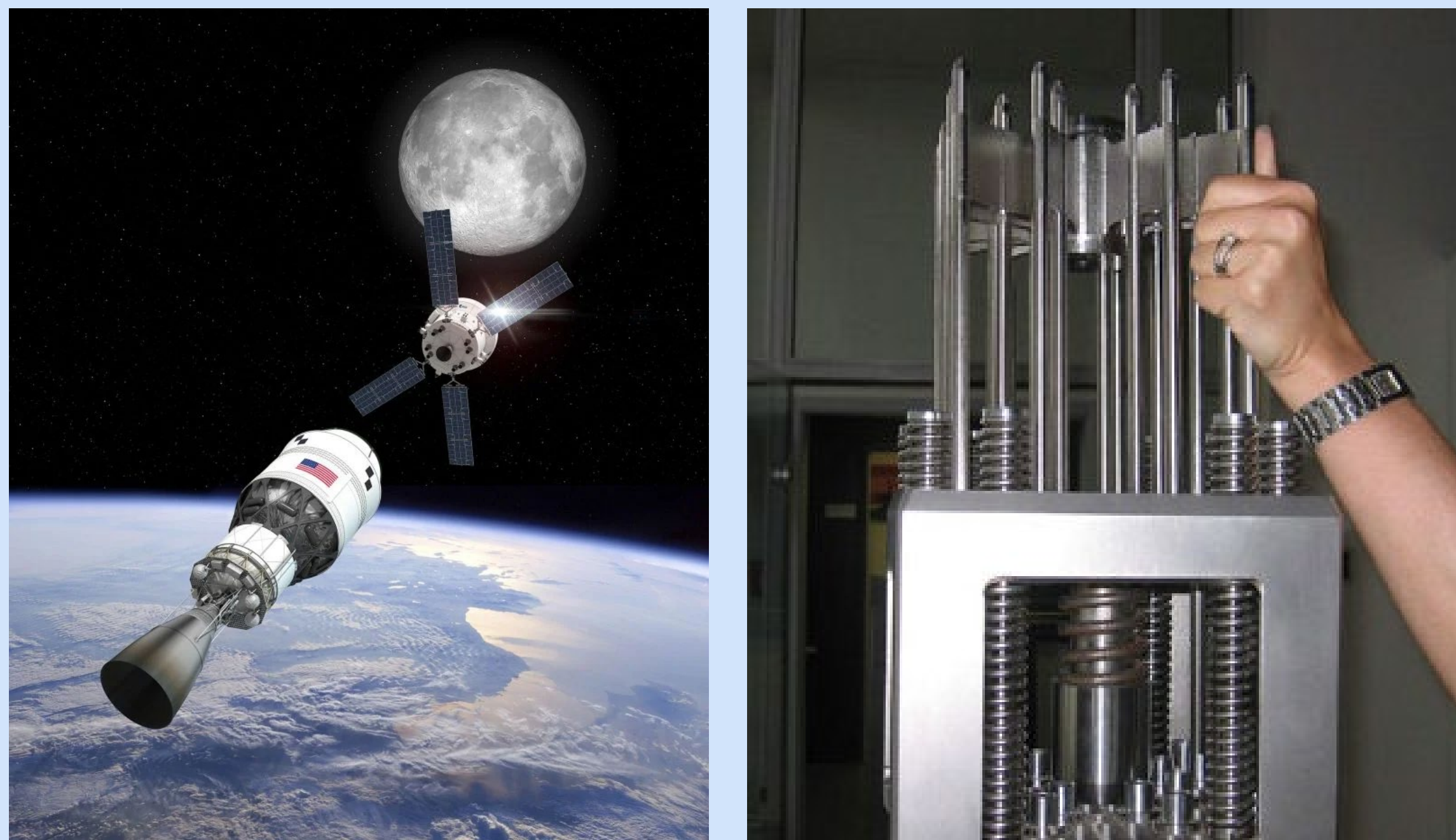


Introduction

- Hafnium carbide (HfC) has one of the highest melting points of any known solid, >4000 °C
- High temperature applications, like nuclear energy and spacecraft
- HfC synthesis typically requires multiple steps and is inefficient
- SHP-199 polymer is a commercially available precursor for simple HfC synthesis



Motivation

- SHP-199 polymer produces HfC ceramics upon pyrolysis to 850 °C, which is a relatively quick and efficient synthesis
- Resulting ceramics are very delicate and have poor mechanical properties
- Performing chemistry on the polymer may improve the resulting ceramic's mechanical properties

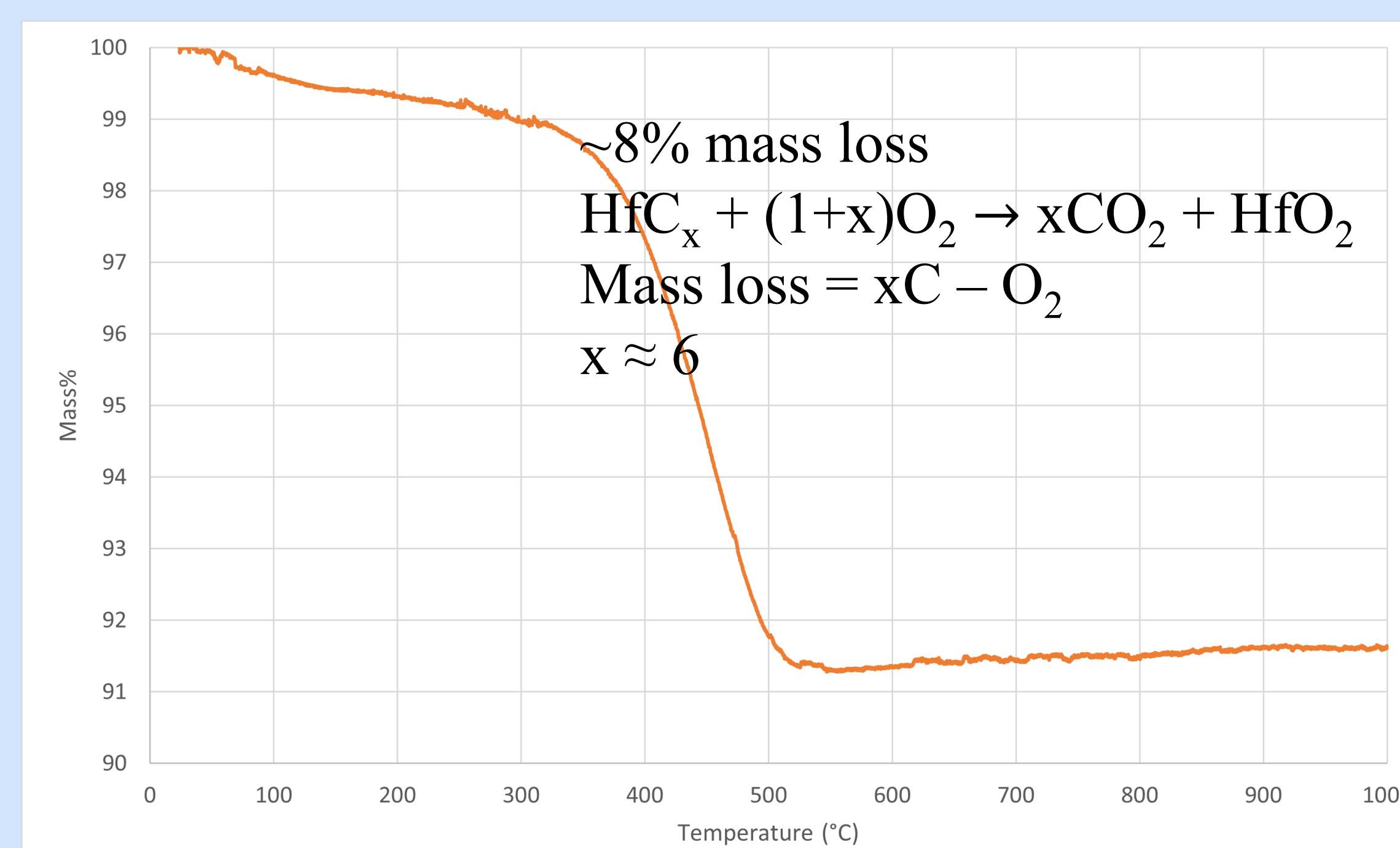
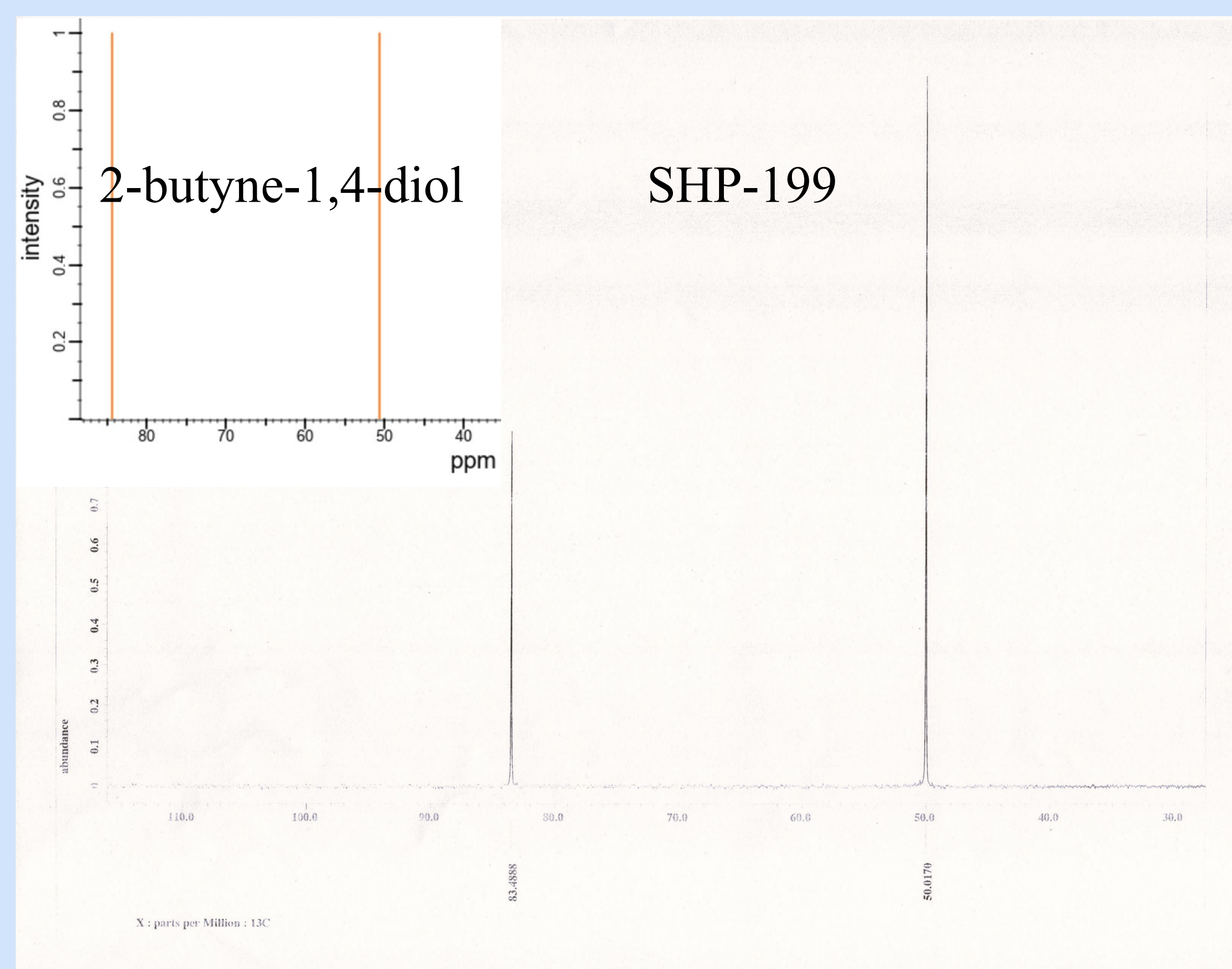
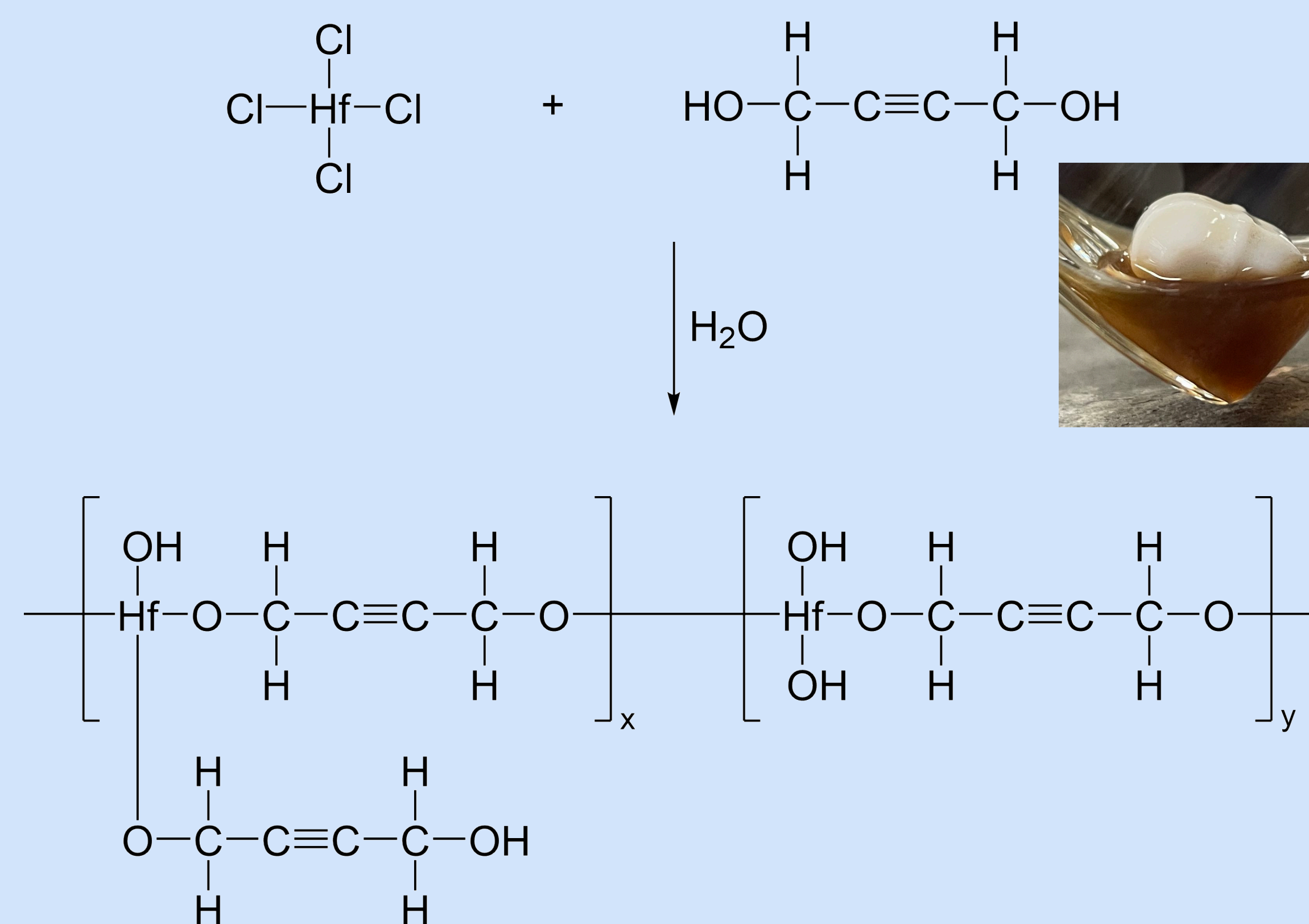


Templated Foam Ceramic

- Polyurethane foam impregnated with neat SHP-199
- Foam pyrolyzed under N₂ atmosphere to 1000 °C
- Polyurethane burns away and HfC network is left behind in the shape of the foam template
- Foam falls apart with any mechanical stress

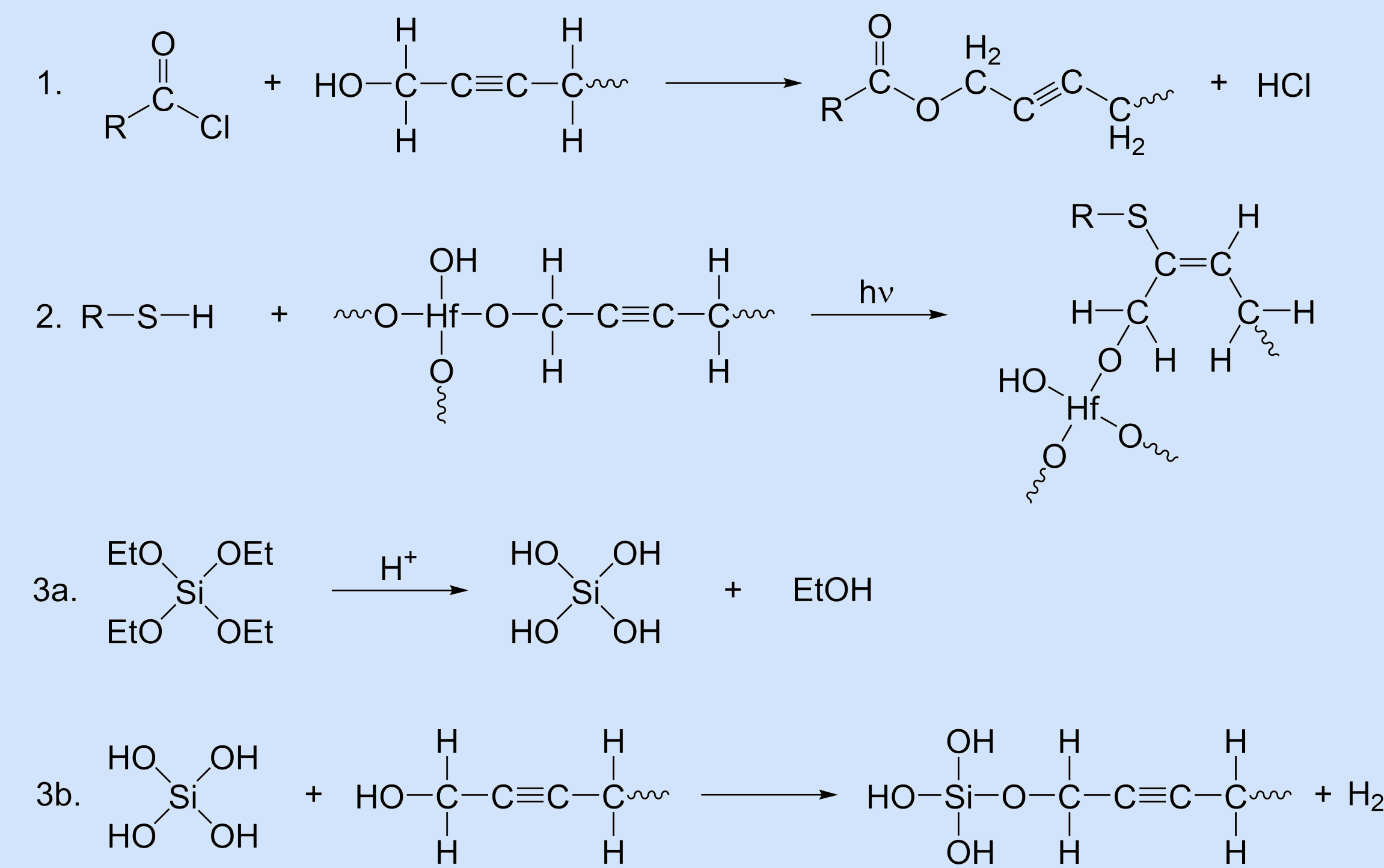
Proposed Polymer Structure

- Hafnium tetrachloride and 2-butyne-1,4-diol reacted in presence of water at 150-200 °C
- Structure supported by ¹³C NMR evidence
- Thermogravimetric analysis under air of HfC ceramic material to estimate carbon content
- Estimated 1:6 Hf:C atom ratio, 1:1 X:Y monomer ratio



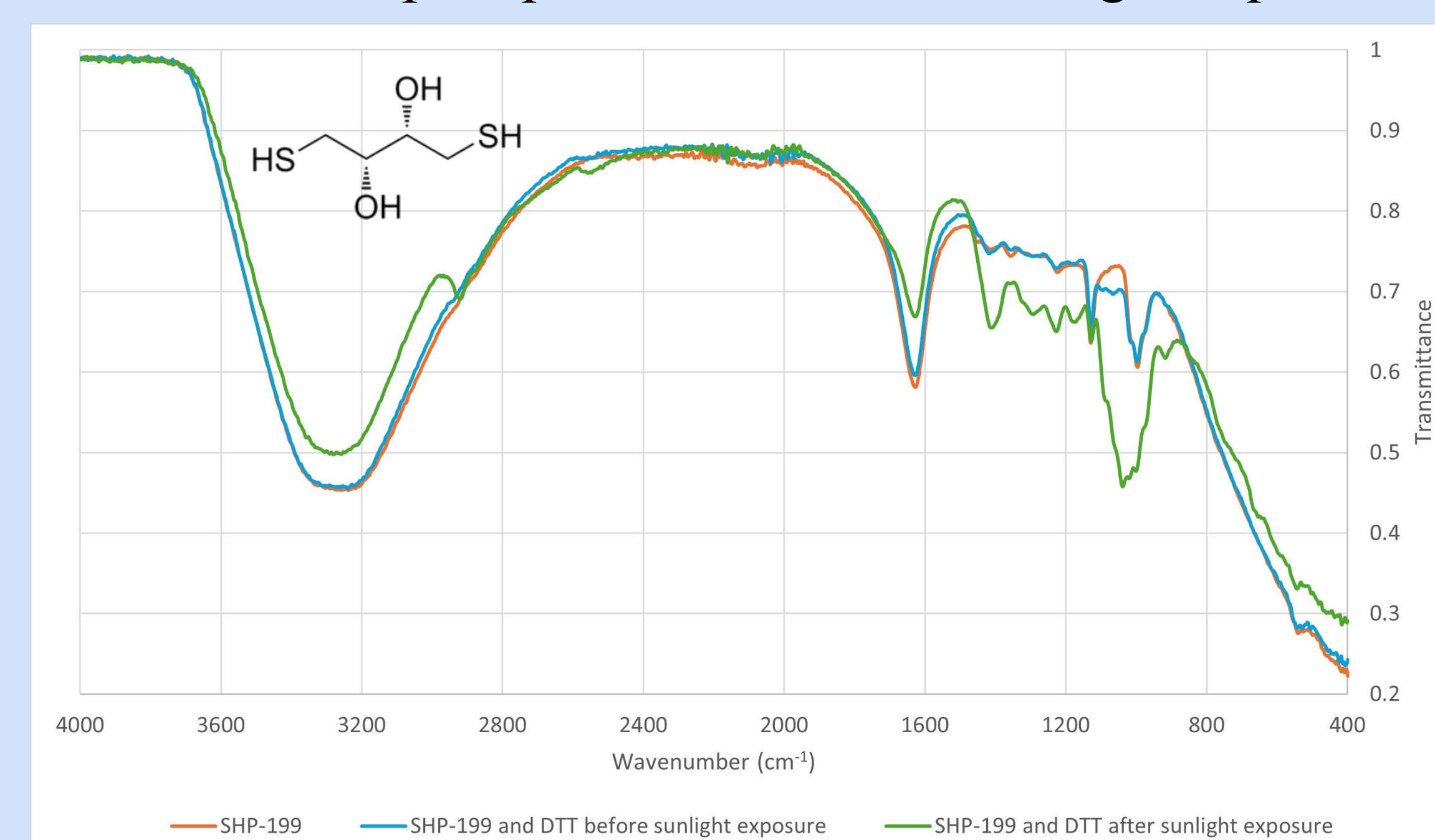
Proposed Reactions

- Nucleophilic acyl substitution by an acyl chloride
- Thiol-yne click reaction catalyzed by light
- Hydrolysis of tetraethoxysilane (TEOS) and co-dehydration crosslinking
- Mono-functional reactant for polymer modification, or multi-functional reactants for crosslinking



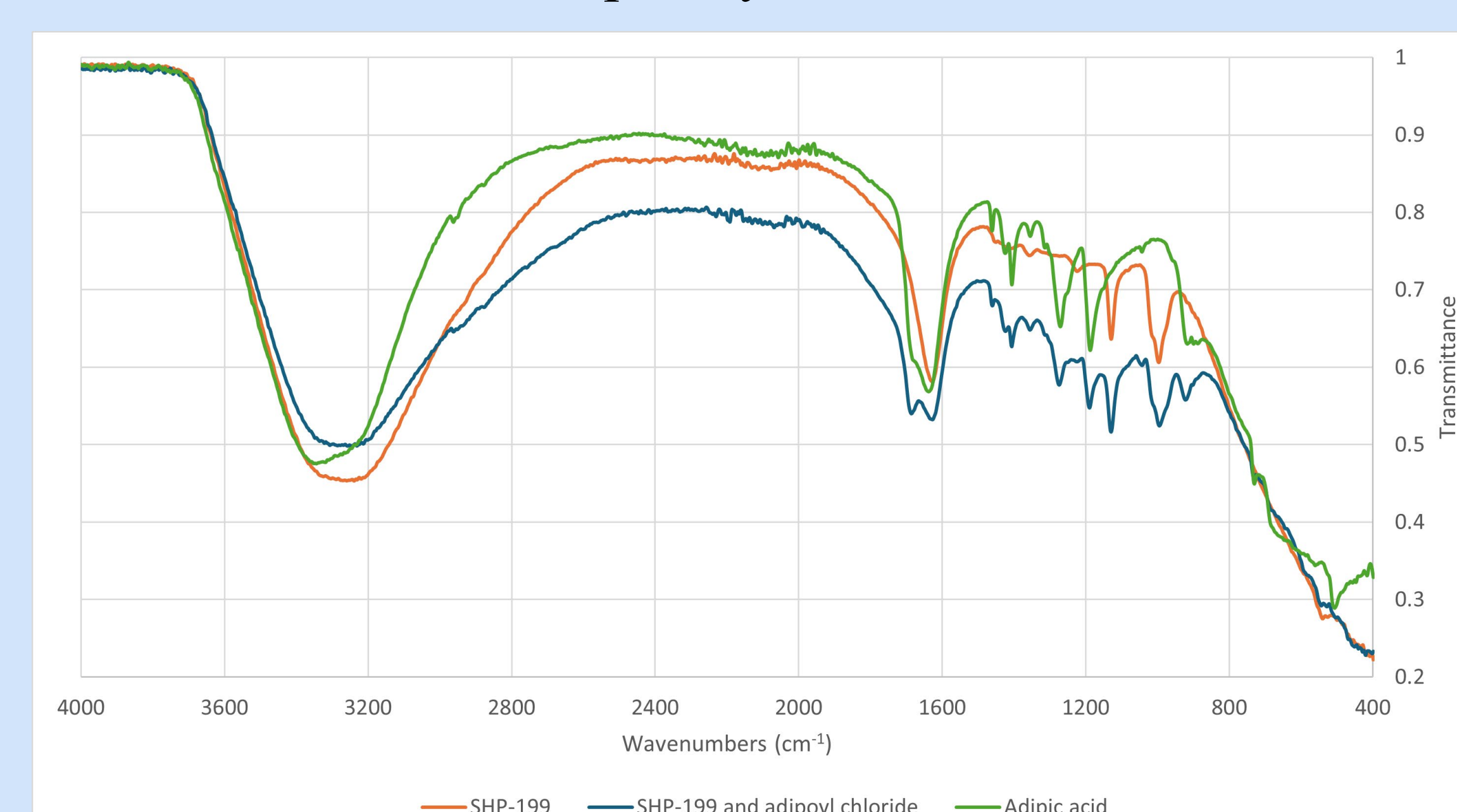
Reaction with Dithiothreitol

- Small solid precipitate formed after sunlight exposure



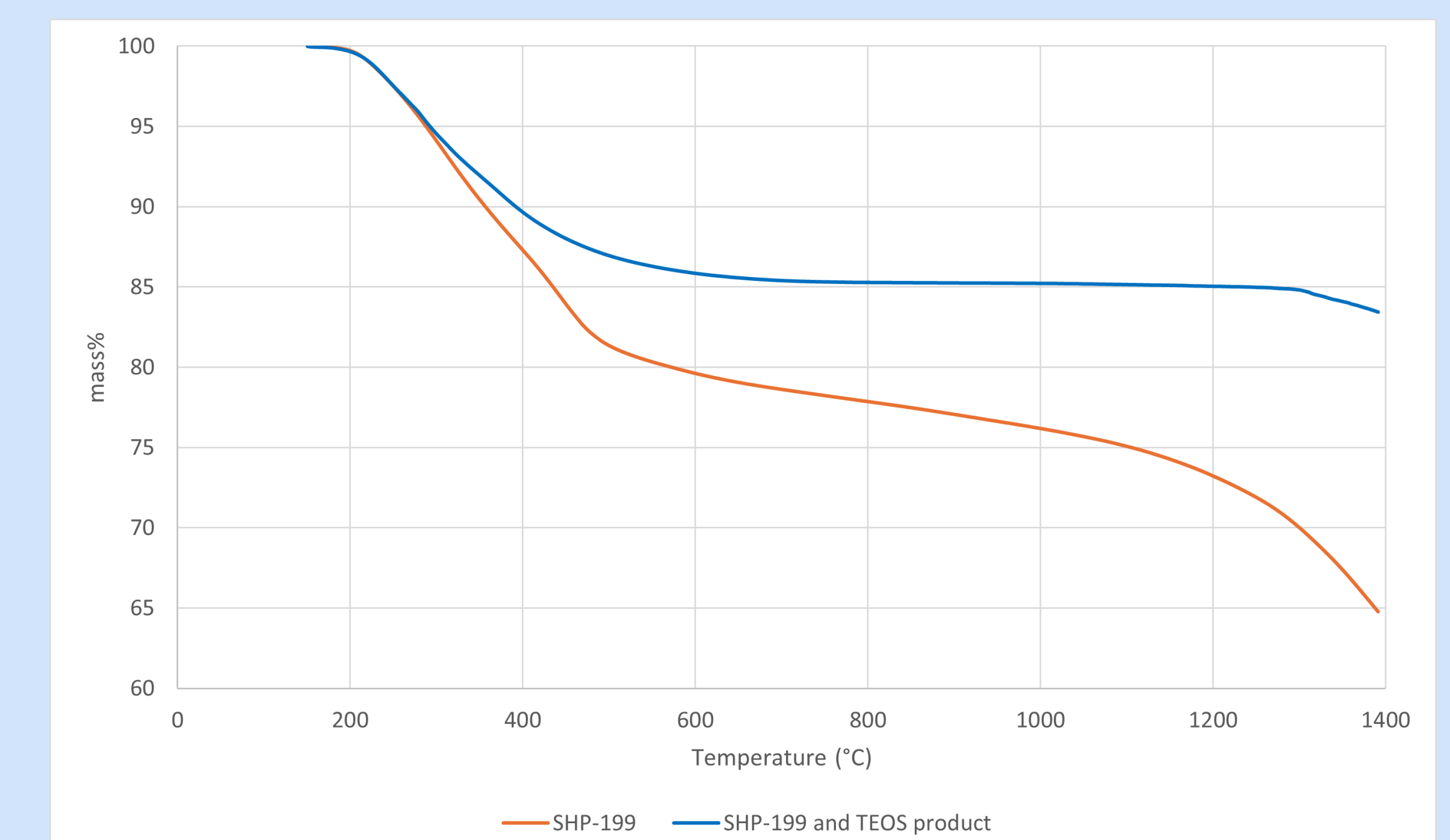
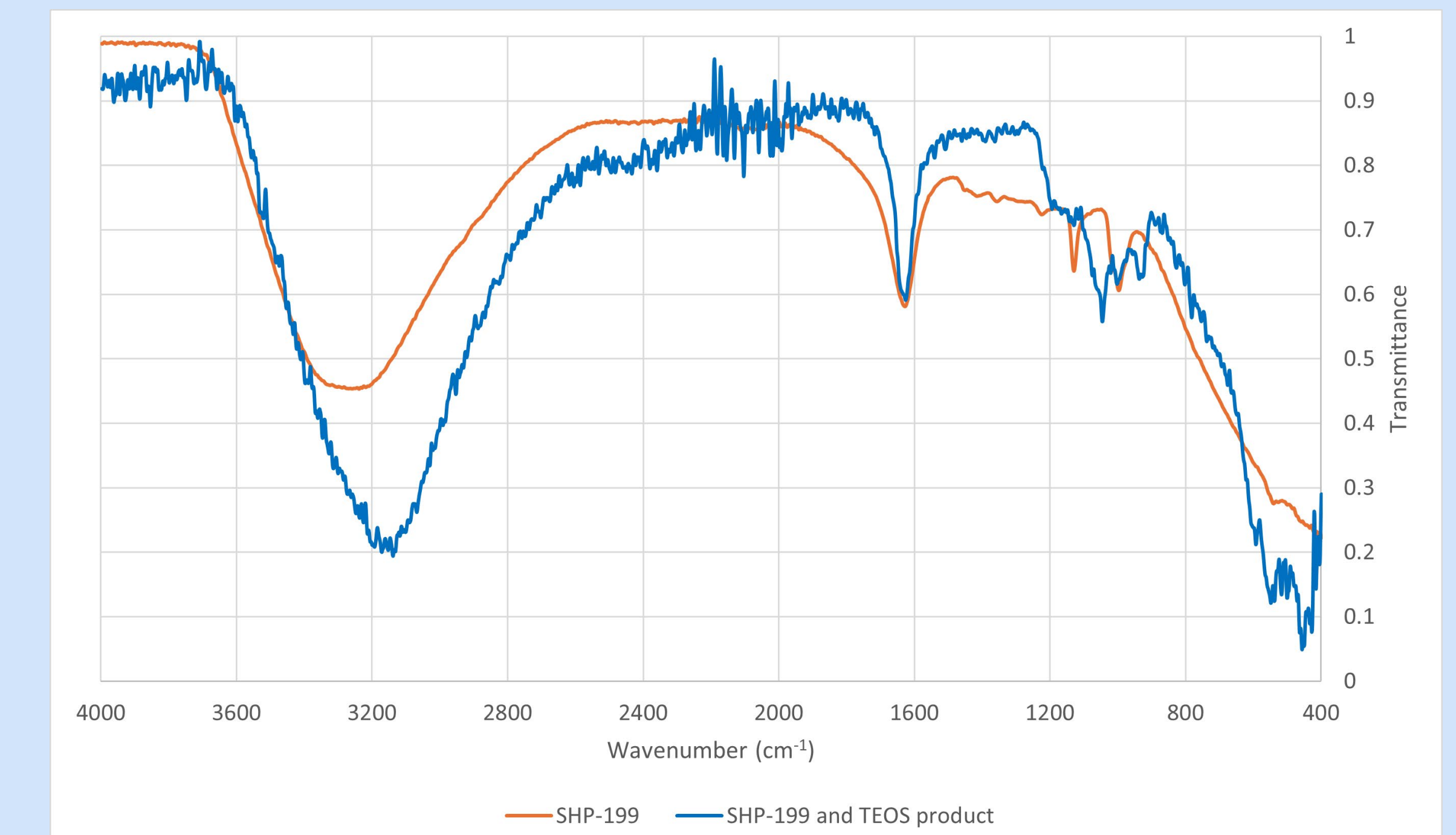
Reaction with Adipoyl Chloride

- Mixture turned completely solid



Reaction with TEOS

- Solid precipitate formed and was washed with acetone and ethanol
- Supernatant turned from dark brown to mostly clear



Future Works

- Pyrolyze bulk amounts of reacted SHP-199 and evaluate mechanical differences
- Study the effect of different solvents on the polymer
- Produce a porous HfC material

References

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